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ABSTRACT

This report outlines the development of the UDECOM system (UNIVAC-DIGITAL EQUIPMENT CORPORATION DATA COMMUNICATION SYSTEM). UDECOM is the implementation of a software package for the DEC PDP-8/I computer which enables data communication with the UNIVAC 1108 computer. Also described are the results of research into the U1108/U1004 data communication system. The functional description of the PDP-8/I and the associated DEC DP01 data communication channel and AT&T 201-A3 data set is defined. The UDECOM system design section outlines the proposed design and implementation phases of the communication system. Finally, the current status of the project is outlined. (RR)

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JDECOM – A U-1108, PDP-8/I DATA COMMUNICATION SYSTEM

Franklin G. Peters

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UDECOM — A U-1108, PDP-8/I DATA COMMUNICATION SYSTEM

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VLADIMIR SLAMECKA
Project Director

ABSTRACT

This report outlines the development of the UDECOM system (UNIVAC-DIGITAL EQUIPMENT CORPORATION DATA COMMUNICATION SYSTEM). UDECOM is the implementation of a software package for the DEC PDP-8/I computer which enables data communication with the UNIVAC 1108 computer. The basis of the design is to use the PDP-8/I as a model of the UNIVAC 1004 remote system in the U1108/U1004 data communication environment. The UDECOM system is designed such that the PDP-8/I appears to the U1108 exactly as a U1004.

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INTRODUCTION

The basic objective of the project is to design and implement the software system necessary for the PDP-8/I to model the U1004 remote system in the U1108/U1004 data communication environment. The UDECOM system is designed to be functionally identical with the U1108/U1004 system with respect to the data communication link.

The UDECOM system will enable direct data communication between the PDP-8/I in the Information Science Laboratory and the U1108 located in the RECC. The PDP-8/I will be functionally identical in terms of data communication linkage with the U1004. The design of UDECOM, specifically as an input/output data communication driver, will allow significant flexibility in utilizing the PDP-8/I and associated peripheral devices as a remote terminal for the U1108 as well as provide for the Information Science Department the use of both a small scale general purpose data processor and a large scale computer from the remote facility.

The first section of this report describes the results of research into the U1108/U1004 data communication system. Much of the published data did not prove adequate for our purposes, thus a continuing exchange of information with UNIVAC personnel is required to collect valid information. In order to model the U1004, it is necessary to develop an exact definition of the functional operation of the remote system and its interface with the U1108.

The functional description of the PDP-8/I and the associated DEC DP01 data communication channel and AT&T 201-A3 data set is defined in the next section of the report. The description includes the nature of the specific interface necessary to enable the data communication link in the PDP-8/I environment.

The UDECOM system design section outlines the proposed design and implementation phases of the communication system. The current status of the project is outlined in the last section of this report, as well as a milestone chart covering the portions of the projects remaining.

THE U1108/U1004 DATA COMMUNICATION SYSTEM

The U1108/U1004 Remote System is patterned after the 1107/1004 Remote System. Control over the input/output stream is given to the 1004 operator with some exceptions. This control is exercised by the 1004 operator through the use of the four alteration switches on the 1004. The first three switches on the 1004 are used in combination to select a control character for transmission and the fourth switch is the execution switch. This control character is sent to the 1108 in the form of a command message which must be acknowledged by the 1108. All messages sent between the two systems are acknowledged in some manner as being good or bad. In the case of acknowledgment of a good message, the operation continues; for a bad acknowledgment, the message is retransmitted until properly received. In this Remote System (RMS1) under the 1108 EXEC VIII operating system, only 80 column operations are allowed. These include read, write and punch. All codes shown in this document are in the internal XS3 code of the 1004 except when the subscript "8" is used to indicate octal.

Operations

The initial operation is to establish the data communication connection between the two systems. This is accomplished by the 1004 operator establishing voice communications with the 1108 operator so that the AT&T 201A3 data sets can be set to "DATA." When this connection is established, the 1004 operator notifies the 1108 system that this remote site is ready for transmission by transmitting the "READY" command to the 1108. This is done by setting alteration switches 1 and 4. Upon receipt of the "READY" the 1108 system acknowledges by either initiating any output files queued for this site or beginning to probe the 1004 at about 6 second intervals. It should be noted that each remote site has an identification number which is included in the command message. When the 1108 system is in the probe state, the 1004 operator will be aware of this situation by the control indicator lights on the 1004. Now the 1004 operator can begin operations by sending the appropriate command.

The 1108 operator can cause termination of operations through the "SR" keyin. In such case a "HALT-GO VOICE" can be sent to the 1004 operator in case a situation arises which necessitates voice communication between the operators. This corresponds to the 1004 "HALT-GO VOICE" message initiated by the alteration switches.

U1004 Alteration Switch Options

1. ALT #1 — READY - notifies the 1108 system that the 1004 is now ready to begin operations. The 1108 Remote System then begins to probe the 1004 and maintains communications until commanded otherwise.

2. ALT #2 — READ - notifies the 1108 system that the 1004 is ready to read one or more RUN files and submit them for execution. Each RUN file is headed by a @ RUN control card. The end of file is signaled by an End-of-Deck card.

3. ALT #3 — HALT - notifies the 1108 system that all communication is to stop on this channel until a READY message is received from the 1004.

4. ALT #1,2 — HALT-GO VOICE - same as the halt except that the 1108 operator is notified to switch the data set to TALK for voice communication.

5. ALT #1,3 — ABORT PRINT - notifies the 1108 print symbiont that the remainder of the present file is to be ignored and that printing is to resume with the next file, if any.

6. ALT #2,3 — ABORT RUN - same as ABORT PRINT except with the punch symbiont.

7. ALT #1,2,3 — OFF LINE - this command indicates that the 1004 operator is ready to relinquish the channel. It is normally used to terminate remote operations. The 1108 Remote

System prepares for terminations in the following manner:

1) If input is being accepted from the 1004 when the OFF LINE command is received, transmission is continued until the 1108 receives the END INPUT command.

2) If output is in progress when the OFF LINE command is received, the output file is completed before termination.

Message Control Characters

The message composition of the 1108/1004 Remote System consists of a string of data characters imbedded in a group of message control characters. These message control characters consist of synchronization codes, start of message indicator, end of message indicator, message parity character and end of buffer character. All messages between the two systems are formulated with these characters. Unless otherwise indicated, all characters consist of a six bit code plus a parity bit, and are in odd parity.

The sync codes that precede the message place the receiving hardware in phase with the sending device. A series of four contiguous sync codes are always used and they correspond to 065_8. Although these characters are stripped off the message by the receivers, they must be provided by the sending device. The next character represents the start of message (SOM) indicator. It is represented by 100_8 or an XS3 blank. This is the first character handled by the receiving software.

After the SOM, the data characters of the message follow, with only two lengths allowed: six characters for a command message, and 330 characters for a data message. All characters must be in odd parity. The end of message is indicated by the end of message (EOM) character of 125_8 or an XS3 "B". Upon receipt of the EOM, the receiving system will process

one additional character. This next character represents the message parity (longitudinal) and is the exclusive "OR" result of all preceding characters including the SOM and EOM. Even though this is the last character to be processed, there is one additional message control character that must be provided by the sending system. The last character provided is the end of buffer (EOB) character of 041_8 or an XS3 "*". It is eliminated by the receiving hardware. The output data message from the 1108 does not provide an EOB character.

U1108 Message Content

Messages appear to the 1004 from the 1108 in two forms. One form is that of a function command and the other is a combination of a function command and a data message.

Function command messages are six characters in length, the first being the function code and the remaining five disregarded by the 1004. The chart below shows the function code sent in a command message from the 1108 and the corresponding action taken by the 1004. XS3 code is shown in parenthesis.

FUNCTION CODE	1004 ACTION
010_8 (5) and 111_8 (6)	Output: Print and Punch
144_8 (J) and 045_8 (K)	Read
127_8 (D)	Probe Response
025_8 (B)	Halt
057_8 (Δ)	Retransmit

The second form of message is an output data transmission from the 1108 consisting of an output command message, followed by a compressed data buffer with its own message control characters. In this special case, since the two messages are end to end, the EOB character is deleted from

the command message. The 1004 considers this single transmission as two due to the intervening sync codes.

The 1108 function command appears as follows:

Command

S	S	S	S	SOM	F	F	F	F	F	F	EOM	MP	EOB

where: S - sync codes - 065_8

SOM - start of message - 100_8

F - function code and five disregarded characters

EOM - end of message - 125_8

MP - message parity

EOB - end of buffer - 041_8

The 1108 function command and data message combination:

Output

S	S	S	S	SOM	0	XXXXX	EOM	MP	S	S	S	S	SOM	← 330 characters →	EOM	MP	EOB

where 0 - output function code - 010_8 or 111_8

X - disregarded characters

U1004 Message Content

The 1004 sends four types of messages. Three of these are command messages, which utilize a control character to indicate to the 1108 what operation is to be performed. The data buffer message is the fourth type.

Command messages consist of READY, ACKNOWLEDGE and RETRANSMIT. The ready command is distinct in that it contains the site code identification in addition to the control character. In the acknowledge command, the unused five characters are blanks; this type of message is used as a carrier for all control commands except for the initial ready. The retransmit message is of the same form as the acknowledge except that it has a special control character.

A summary of control characters (CC), alteration switch settings (AS) and the corresponding 1108 action follows:

CC	AS	1108 ACTION
100_8	N/A	No Change
004_8	N/A	Retransmit
105_8	1,4	Ready Response
106_8	2,4	Read
007_8	3,4	Halt
010_8	1,2,4	Halt-Go Voice
111_8	1,3,4	Abort Print
112_8	2,3,4	Abort Punch
013_8	N/A	End Input
114_8	1,2,3,4	Off Line

Switch 4 is the 1004 execution switch.

Three of the commands are not generated by the alteration switch settings; they are created internally in the 1004 under certain conditions. When a setting is made in switches and executed, the next transmission to the 1108 contains the appropriate control characters, at which time the switches are internally cleared and the no change code is used in replies until a new entry is executed on the switches. If the last 1108 message received requires retransmission, the retransmit command is sent to the 1108. One special condition that arises is the end of file on a file to be transmitted to the 1108. This condition causes the end input message to be transmitted to the 1108.

The data message sent by the 1004 is a 330 character compressed data buffer.

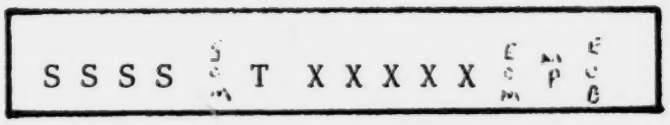
The 1004 ready message appears as follows:

Ready

where: R - Ready Control character - 105_8
C - Site code identification

The 1004 remaining command messages:

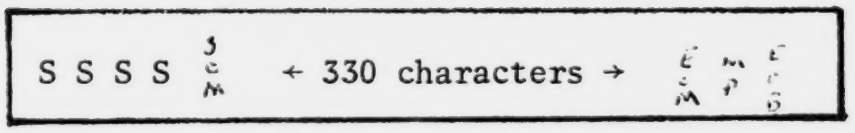
Acknowledge
Retransmit



where: T - control character

The 1004 data messages:

Read



System State

The 1004 is considered at all times to be in some "state", which is represented by the control characters. Since for every transmission from the 1004, a control character is included, the 1108 always knows the state of the remote. Except with the ready, when the status is sent to the 1108 the alteration switches are cleared internally and the no change code remains the status character until end of the 1004 file on READ operations, or the operator executes a new switch setting or a retransmit is required from the 1108.

Read Operation - 1004 to 1108 Data Transmission

Once communication has been established and the 1108 is in probe status, a read operation is initiated by the 1004 operator by setting the appropriate switches. This causes an acknowledge message with control code 106_8 to be

sent in response to the probe. When received by the 1108, a read function command message is sent back to the 1004. The read routine in the 1004 begins to compress data for transmission. The compression routines will be discussed in a subsequent report. When the output buffer is filled, the appropriate message control characters are appended and the data message is transmitted. When end file is detected by the 1004, the current output buffer is transmitted, and an end input function command message is generated and transmitted. Upon receipt of the end input message, the 1108 read symbiont terminates and the 1108 enters probe status.

To insure that no data is lost during transmission, a method of identifying each buffer called "buffer count" is used. Upon receipt of each data message from the 1004, the 1108 prepares and transmits a read function command. The function code may be 144_8 or 045_8; the low order bit of the function code alternates identifying the present read function command as unique from the last one. If a retransmission is required, the same read function command is sent to the 1004 as the last one so that the 1004 retransmits the same message. If retransmission is not required, the alternate read function command is sent to the 1004.

Output Operation - 1108 to 1004 Data Transmission

When the 1004 is in ready status, the remote site is ready to receive output from the 1108. The actual transmission is in two parts, each separated by four sync codes. After a control routine has determined that this is an output function, it accepts the 330 character compressed data buffer. The 1004 decompresses the buffer until the end of data in this buffer is found, a good acknowledge message is built and sent to the 1108 and the cycle repeats until the output file is complete.

In the output operation, the "buffer count" scheme is used as in the read operation. The function command portion of the output transmission contains either a 010_8 or 111_8. If the previous output was received properly by the 1004, the next output will have the alternate code. When

the output is received from the 1108, and determined to be bad, a retransmit command message is sent to the 1108 which in turn replies with the same output message previously transmitted. When the output is received properly, the decompression routine processes the message and an acknowledge message is sent to the 1108 (the ready message without site identification).

THE PDP-8/I AND DATA COMMUNICATION

The configuration of the PDP-8/I that is currently available in the Information Science Laboratory is as follows: an 8K main frame, an ASR33 teletype station, a Motorola card reader, a PT08 teletype option, a high speed paper tape reader/punch, two DECtape transports, a DP01A data communication channel tied to a 201A3 Dataset and an A-D converter. We are awaiting delivery of a storage scope and a 512K word disk.

The 201A3 data set operates at a fixed speed of 2000 bits per second. It accepts binary data in serial form from the DP01A for transmission and delivers it to the DP01A in receiving mode. When the DP01A wishes to transmit, it changes the polarity of the "request to send" lead. When the data set is ready to transmit, it returns a "clear to send" signal to the DP01A. When carrier is established at the distant data set, a "carrier on" signal and clock signals are supplied to the business machine at the distant receiving terminal. This handshake operation is independent of program control with the exception that it is initiated when the DP01A is activated by the first sync code provided before transmission.

The data set transmitter interface terminals of interest are: the serial clock (transmitter) synchronizes data with transmitter timing and the send data line (transmit) accepts data to be transmitted. The receiver interface terminals are: the serial clock (receiver) which synchronizes receiver timing circuits and the received data line which provides received data to the DP01A.

The DEC DP01A data communication channel is an interface between the PDP-8/I main frame and the 201A3 Dataset. The DP01A consists of two basic assemblies, a control section and a computer interface section. The control section performs serial-to-parallel and parallel-to-serial conversion as well as Dataset control. The interface section adapts the control section to the input/output bus of the PDP-8/I main frame.

The two independent serial channels of the DP01A are controlled by programmed IOT instructions from the PDP-8/I, and synchronized by timing

pulse streams from the associated 201A3. Output characters are transferred in parallel from the computer to a buffer register, then serially shifted to the Dataset. Input characters from the Dataset are shifted into a register, transferred to a buffer register and made available to the PDP-8/I on an interrupt basis. Control of the DP01A is also through IOT commands.

Our DP01A is set up to process seven bit characters (six data bits plus parity). Synchronization between the DP01A and the distant data terminal is established by a sync character code. Once a sync character is detected, the hardware is set up to assemble every seven consecutive bits to form a character when the DP01A is receiving. Serial data is transmitted and received continuously once synchronization is achieved (the channels are asynchronous). The transmission format consists of sync characters followed by characters which make up the text of the message. The standard sync character employed and recognized by the DP01A for seven bit character processing is 026_8. However, since we are modeling the 1004 in the 1108/1004 environment, a hardware change is necessary in the DP01A sync character detection circuits. The 1004 transmits and accepts a 065_8 and the DP01A modification allows use of this sync character.

The data communication system computer interface operates from the PDP-8/I I/O bus, responding to programmed IOT instructions assigned to the DP01A data communication channel. The IOT commands assigned to the DP01A are described on pages 4-1 and 4-2 of the DP01A Data Communication Channel Instruction Manual, DEC-08-I8BA-D. The IOT instructions transfer parallel data to and from the character assembly logic, set or reset control circuits and test control flags.

Output data is transferred from the PDP-8/I accumulator to a buffer register and then under control of Dataset timing signals, transferred to a shift register and shifted serially to the Dataset for transmission. The input circuits operate in reverse, assembling serial data from the Dataset until the shift register contains a complete character. The

character is then transferred to the buffer register and held until it can be read by the computer.

Receiving Channel - DP01A

Serial data on the line from the Dataset is continually assembled in a shift register under control of a timing pulse stream (serial clock receive) from the Dataset. When an incoming sync character (065_8) is detected, a sentinel bit is set in the most significant bit of the receiving shift register. The next incoming character is fully assembled when the sentinel bit is shifted out of the least significant stage. At that time the assembled character is transferred to the receive buffer register, a program interrupt request is generated and a new sentinel bit is inserted into the shift register most significant stage. The program responds to the interrupt request with an instruction which loads the assembled character into the PDP-8/I accumulator. This sequence is repeated for every character until the Dataset clock stops, at which time another program interrupt request is triggered which indicates the end of the transmission. The "receive active" mode is entered again when a sync character is received.

Transmitting Channel - DP01A

The DP01A transmit logic enters the "transmit active" mode when the program loads a sync character for transmission. Thereafter, data characters are shifted out to the Dataset under control of the transmit pulse stream from the Dataset. Data must be made available for transmission as it is needed since every 7 bits are considered to be a character at the receiver.

In the normal "transmit active" mode of operation automatically initiated by the first sync character of a new transmission, the DP01A will stop transmitting if a new character is not made available in a prescribed interval. When a character is shifted out of the shift register a program interrupt is generated which indicates that the transmit buffer

is ready to accept another character for transmission. The transmission sequence continues until the PDP-8/I fails to deliver a character before the next timing pulse. At this time the transmit logic is reset and waits for another sync character.

Exclusive OR Option

The computer interface section of the DP01A has an exclusive OR buffer which facilitates longitudinal message parity checking and generation on incoming and outgoing messages. The logic of the exclusive OR command is indicated by the logic of a single stage:

Previous OR buffer bit	Accumulator bit	New OR bit
0	0	0
0	1	1
1	0	1
1	1	0

In summary, with the modified sync character detection circuit, the PDP-8/I may be programmed to exactly model the 1004. The 1108 will interface with the PDP-8/I exactly as it does with the 1004. Utilizing compatible messages, parity checking, identical sync codes and compression/decompression routines the PDP-8/I under appropriate control will model the 1004 both in read and output mode.

UDECOM

The objective of this project is to establish a data communication link between the UNIVAC 1108 and the PDP-8/I. The task is accomplished by using the PDP-8/I with associated hardware and software to model the UNIVAC 1004 remote terminal in the 1108/1004 data communication system.

The 1004 is currently being used as a remote batch processor in relationship to the 1108. In order to achieve the greatest flexibility from the standpoint of the user, UDECOM has been designed specifically as an input/output data communication driver. Under this concept, UDECOM may be assembled as a module in a user program requiring data communication capability with the 1108. UDECOM is an independent data communication processor which establishes the communication link under control of the PDP-8/I operator and processes data from the user program for transmission to the 1108 and delivers data from the 1108 to the user program. Data for transmission is fed to UDECOM and data is received from UDECOM under control of a parameter list which establishes the inter-module communication between UDECOM and the user program. All input/output work areas utilized for transmission or receiving by UDECOM are double buffered so that one can be compressed or decompressed while the other is in the input/output state.

UDECOM is composed of five basic sections:

1) the PDP-8/I operator interface routine;
2) the user program interface routine;
3) the compression/decompression routines;
4) the communication system input/output processor;
5) the interrupt handler.

PDP-8/I Operator Interface Routine

This routine is responsible for continually monitoring the condition of the sense switches of the PDP-8/I. Through the sense switches the operator exercises control of the communication system. In addition, the

routine performs functions necessary to establish initial communication, interpret initialization command messages from the 1108, provide initialization command messages to the 1108 and terminate communication when required. The operator is made aware of the status of the system via teletype messages.

The first operation to be performed is that of checking the data communication facilities to insure that a communication link may be established. For transmission to the 1108, this routine sends an initial ready message to the 1108 signaling that the PDP-8/I is ready for transmission. For the READ operation, the operator sets the appropriate switches and in response to the 1108 probe sends the read acknowledge message. Control is then transferred to the user program interface routine. When the transmission is completed, this routine takes control to terminate communication.

For the OUTPUT operation, when the PDP-8/I is in ready status, the site is open to receive input from the 1108. Control is transferred to the user program interface routine for message handling. At the end of the transmission this routine again takes control to terminate communication.

Since the routine continually cycles looking for new sense switch settings, the operator has the same control over operations as the 1004 operator.

User Program Interface Routine

The user program interface routine operates under direction of the parameter list supplied by the user program. Two modes of operation are available to the user program: READ and OUTPUT. READ enables the user program to transmit data to the 1108 and OUTPUT enables the user program to receive data. Record length for UDECOM is fixed at 80 characters. In READ operations, the routine provides a signal to the user program that it is ready to accept a record for transmission. Since transmission is demand oriented, the record must be available for access immediately and upon

signal the user program must provide the starting address of an 80 character record ready for transmission.

For OUTPUT operations, the routine expects the user program to provide the starting address of an 80 character work area upon demand. When the routine fills the record with received data it signals the user program that the record is ready and expects a fresh work area to be made available.

For READ operations, when the user program signals end of file for transmission, control is given to the operator interface routine for termination of communication. In OUTPUT operations, a signal is provided to the user program upon end of received file. During communication, this routine interfaces with the compression/decompression routines.

Compression/Decompression Routines

For OUTPUT operations, the decompression routine unpacks a 330 character data buffer received from the 1108, performs character and longitudinal parity checking and delivers 80 character records, one at a time, to the user program interface routine. This routine also notifies the user program interface routine upon an end of file condition.

For READ operations, the compression routine packs 80 character records received one record at a time from the user program interface routine, performs operations required to generate the message parity character and fills a 330 character data buffer. When the end output condition is sensed, the buffer is filled out and a signal is provided to the user program interface routine.

Double buffering of data work areas for both READ and OUTPUT operations allows efficient interface with the communication system input/output processor.

Communication System Input/Output Processor

The communication system input/output processor contains the routines which handle processing necessary to service interrupts from the DP01A data

communication channel. The interrupt handler provides correct linkage to this routine for the respective interrupt.

Double buffer control is maintained by this routine for both READ and OUTPUT operations, and buffer starting addresses are provided for the appropriate compression/decompression routine. In addition a signal is provided from the longitudinal parity checking subroutine concerning the validity of the last data buffer provided in an OUTPUT operation. Depending upon this signal, the appropriate acknowledge or retransmit message is sent to the 1108. For READ operations, the routine accepts and interprets the acknowledge or retransmit message and operates accordingly.

The receive flag set interrupt routine simply places the character received in the appropriate input buffer and maintains a character count. When the buffer is full, control is given to the decompression routines, while the next buffer is made ready for input. In the case of the end flag set interrupt, the decompression routine is signaled. When the transmit flag is set the system loads the next character from the associated output buffer and provides it for transmission, also handling buffer alternation.

Interrupt Handler

The interrupt handler module is incorporated in the interrupt routine of the user program and recognizes interrupts relevant to the data comunication channel. Depending on the condition found, the handler transfers control to the appropriate communication system input/output processor subroutine.

There are three relevant interrupt conditions for the data communication channel: receive flag set, end flag set, and transmit flag set. When the receive flag is set, the DP01A has a character assembled from the communication line and it must be read or it will be lost. On an end flag set condition, data transmission to the PDP-8/I has ceased. When the transmit flag is set, the data channel is ready to accept another character for transmission.

In summary, since UNIDEC is essentially only a communications driver, two basic operations are provided to the user of UNIDEC: READ and OUTPUT. READ is the operation of providing output to the 1108 from the user program output area, one 80 character record at a time. OUTPUT provides for accepting input from the 1108 and delivering it to the user program input area one record at a time.

UDECOM Implementation Phases

1) Establish the basic communication link between the 1108 and the PDP-8/I: transmit a 1004 ready message to the 1108 and accept a probe from it. This is the most basic of operations and requires a hardware change to the DP01A sync code recognition circuit before the link can be implemented.

2) Program and checkout the compression/decompression routines, along with character and message parity check and message parity generation routines.

3) Establish the basic READ operation: transmit a 330 character buffer to the 1108 under interrupt control.

4) Establish the basic OUTPUT operation: receive a 330 character buffer from the 1108 under interrupt control.

5) Establish buffer control operations and phase the READ and OUTPUT into the communication system input/output processor.

6) Phase READ and OUTPUT interrupt control into the interrupt handler.

7) Establish the user program interface routine.

8) Establish the operator interface routine.

9) System test and demonstrate UDECOM.

Expected completion dates for implementation phases:

1) April 11, 1969
2) April 18, 1969
3) April 25, 1969
4) May 2, 1969
5) May 16, 1969
6) May 23, 1969
7) May 23, 1969
8) May 30, 1969
9) June 6, 1969

The basic research has been completed and work is currently in progress on Phases 1 and 2.